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above and behind the eye the nasal pit still forms and the olfactory fibers which develop in it grow into the lateral wall of the diencephalon above the eye, which is of course an unusual region for these nerve fibers to enter.

C. R. Stockard.

The Influence of Regeneration on Moulting in Crustacea.—A recent paper by Dr. Margarete Zuelzer[1] furnishes additional data regarding the influences of regeneration, or the replacement of lost parts, on the moulting process in crustacea. It is generally known that the members of this group have the power to grow new appendages, legs, antennæ or swimmerets, after the former ones have been lost through accident or injury. In order to produce the new limb as well as to grow, or increase in body size, the crustacean must moult its hard chitinous shell. The processes of growth are closely associated with moulting and the more frequently the animal moults the faster will it increase in size. When one of these animals has lost a limb it is usually replaced by a small new one during the next moult following the injury.

Since the moulting period is so closely connected with the normal rate of growth several investigators have endeavored to ascertain what effect regeneration might have on the interval between these periods. Zeleny found that crayfish while regenerating their limbs moult faster, or more frequently, than normal individuals, and, further, he holds that an animal regenerating several limbs moults more frequently and regenerates the limbs faster than one replacing a single appendage. He concludes that during regeneration the moulting process is hastened. Emmel, on the other hand, has reached an opposite conclusion from the study of a large series of young lobsters. He finds normal individuals moulting more frequently than others which are regenerating new limbs. Lobsters that have lost several appendages moult slower than those that have lost fewer. Emmel, therefore, believes that regeneration retards the moulting process. He showed very clearly that an important factor, which Zeleny had failed to take into account, was the time at which regeneration was introduced into the moulting cycle. If the limbs were removed the day after moulting the moulting period remained almost normal, but when the limbs were removed four days after the moult the resulting regeneration lengthened the interval before the next moult by eighteen percent. The longer the time intervening between a moult and the removal of appendages the longer the following moult was postponed through the influence of the resulting regeneration, although the less likely was regeneration to ensue.

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[1] Uber den Einfluss der Regeneration auf die Wachstumsgeschwindigkeit von *Asellus aquaticus* L. *Arch für Entwick.-Mech.*, XXV, Dec., 1907.

Emmel's experiments also seem to show that the retarding influence is due to the regeneration phenomenon and not to the injury sustained, since in all of his experiments those animals that failed to regenerate new limbs did not have the moult following the operation postponed.

In the young lobsters the regeneration process retarded their growth at times more than twenty-four per cent.

Dr. Zuelzer, having the contradictory results of Zeleny and Emmel in mind, has undertaken a similar study on the little crustacean Asellus. Agreeing with Zeleny, she finds that in the majority of cases moulting occurs at shorter intervals if regeneration is taking place. The rapidity of moulting depends upon the time elapsing between the last moult and the time of operation, an important factor, as shown also by Emmel.

If the animal is operated upon during the moulting stage or shortly after, the following moult is usually hastened by the regeneration phenomenon. When more time intervenes between the moult and the amputation of the limbs the tendency is to delay the first moult following the operation, but to hasten the second and third moults. Should the amputation of appendages immediately precede a moult the moult occurs normally, but no regeneration is shown, the next moult is retarded and regeneration occurs; the third moult is accelerated and the regenerating limbs increased in size. Occasionally when the operation preceded the moult by a considerable interval no regeneration occurred, although the moult may have been hastened.

When the two antennæ are cut at different levels so as to leave stumps of unequal lengths, the longer one regenerates at a slower rate than the shorter, so that the original equality in length is again established. Zuelzer considers this a case of "compensatory regulation," that is, the short stump influenced the longer one to regenerate slower than it would otherwise have done in order to reestablish their equality in length. This difference in growth rates may be equally well explained as due to the levels at which the cuts were made on the two antennæ, as Morgan has shown for the fish's appendage that the nearer the edge or tip of a fin the cut is made the slower will be the rate of growth of the new tissue.

Repeated amputation, or removal of regenerating buds, continues to accelerate the moulting process. Zeleny has shown in Cassiopea, a jelly-fish, that repeated operation also hastens the rate of regeneration. New tissue grows faster from a cut surface that has previously regenerated tissue than from a newly cut surface that has not before regenerated.

Zuelzer finds, like Emmel, that the moulting time is unaffected, or she believes at times hastened, in those cases where regeneration fails to follow the amputation of appendages. The reason for this she thinks may be that the animal with fewer appendages has a smaller body mass and, therefore, more food to use in normal growth, particularly when none of this food is used to form regenerating tissue. Thus Emmel's lobsters which failed to regenerate moulted more rapidly than regenerating ones. When one considers, however, the apparent unimportance of food-supply on regeneration phenomena as shown by Morgan he becomes disinclined to accept Zuelzer's explanation.

In a general way Zuelzer agrees with Zeleny in that regeneration hastens the moulting process. It is interesting to note that both of these workers have used adult crustacea while Emmel's experiments were made upon larval or young lobsters and gave opposite results. A possible reconciliation of the results may be as follows: The young lobsters, like most young animals, are growing at a maximum rate; all available energy is being used in growth. When such animals are injured they receive a "set-back" since some of their energy must now be diverted in order to repair the injury. Emmel showed that the process of regeneration retarded the rate of growth of these lobsters sometimes more than twenty-four per cent., but when the injury was not repaired growth or moulting was not retarded. Adult animals, on the other hand, are not living up to their maximum possibilities; they are in an apparent state of reserve until the removal of an appendage or other injury excites them to new activities and regenerative growth begins. During regeneration the animal may be said to be in a condition of newly stimulated growth and all growth activities are probably influenced. One may predict that if similar regeneration experiments be tried on the adult lobster the results will agree with those obtained on adult crayfish and Asellus.

C. R. Stockard.